MIT Museum

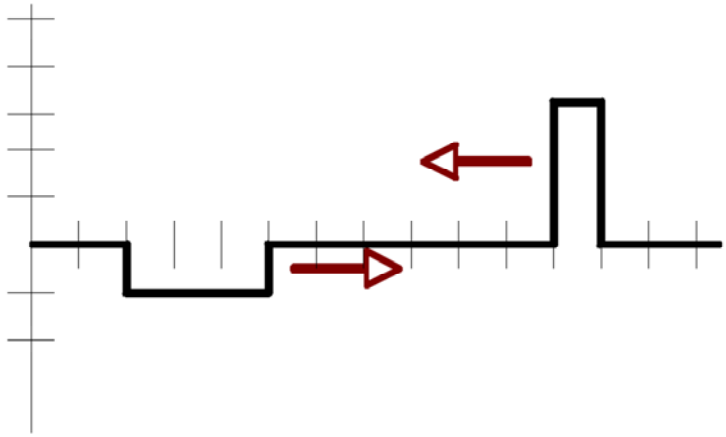
Fourier

What did you learn??

Perception

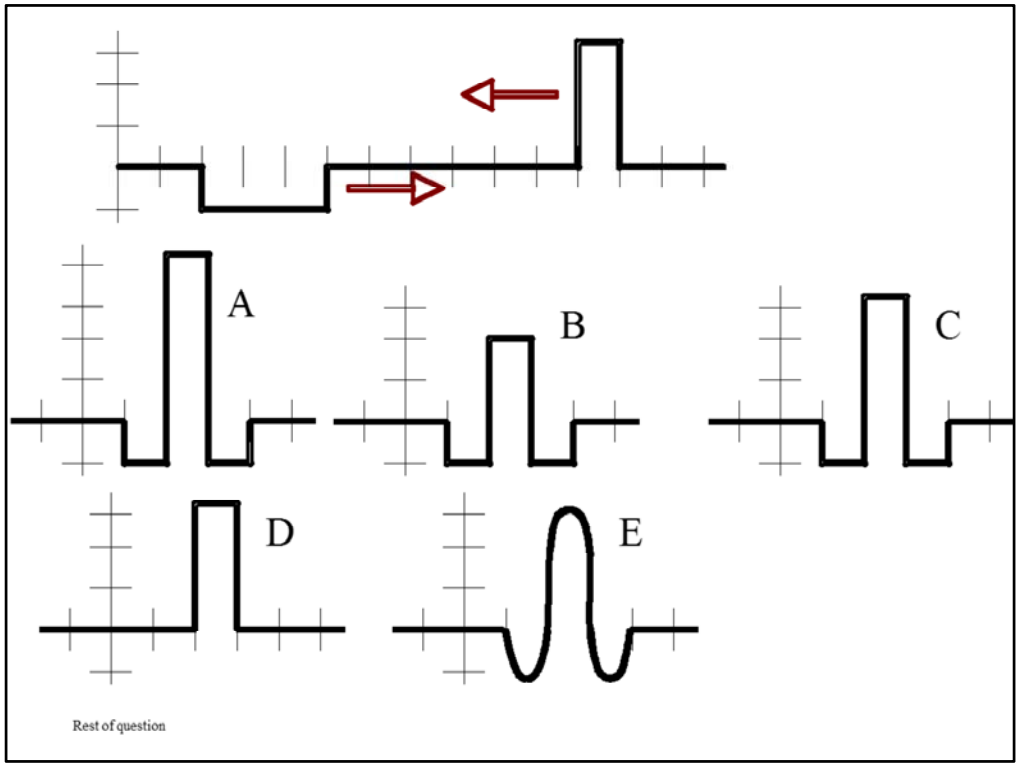
- Can pick out one frequency

1. The pulse on the left is moving right, the pulse on the right is moving left. What do you see when the pulses overlap?

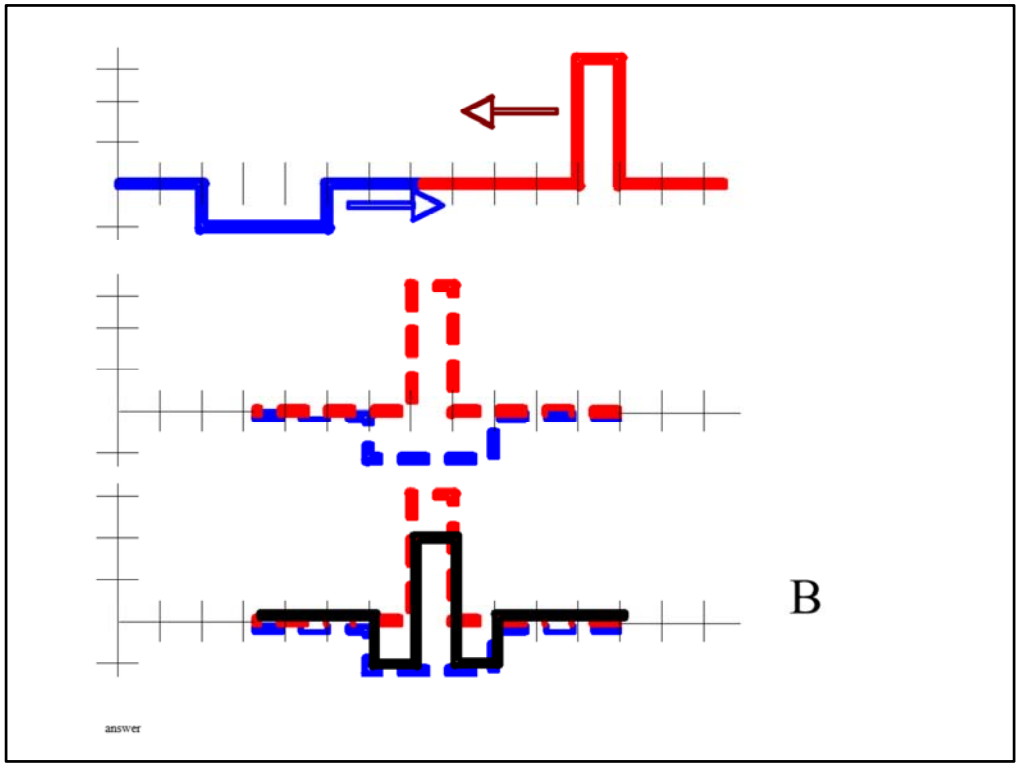


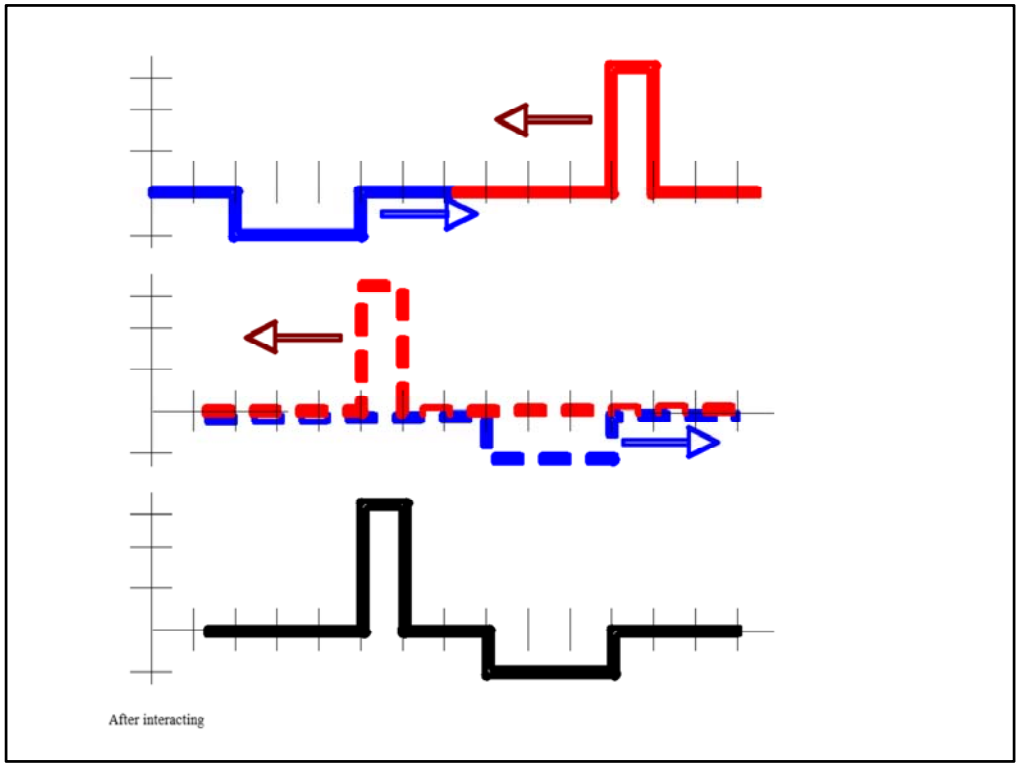
Wave addition simple pulse

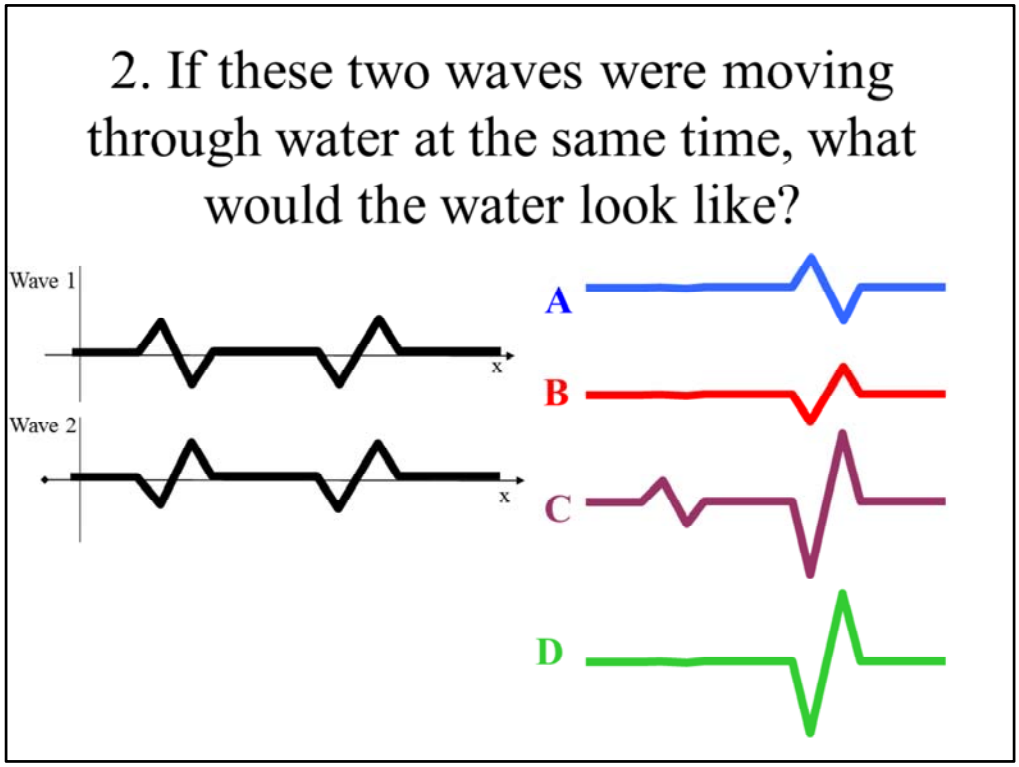
Adapted From Pollock at CU course: Physics of Sound and Music for nonscientists there are a total for 4 slides for this



http://www.physics.nyu.edu/~ts2/Animation/waves.html


B
answer

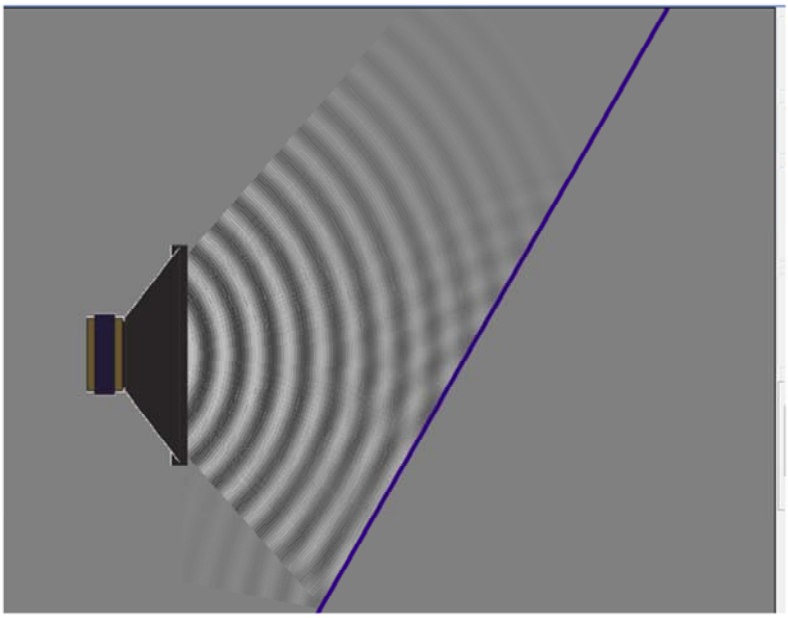

After interacting


2. If these two waves were moving through water at the same time, what would the water look like?
Wave 1
x
Wave 2
x
A
B
C
D

D

Echolocation

Sound bounces off of different materials



Listen for echoes

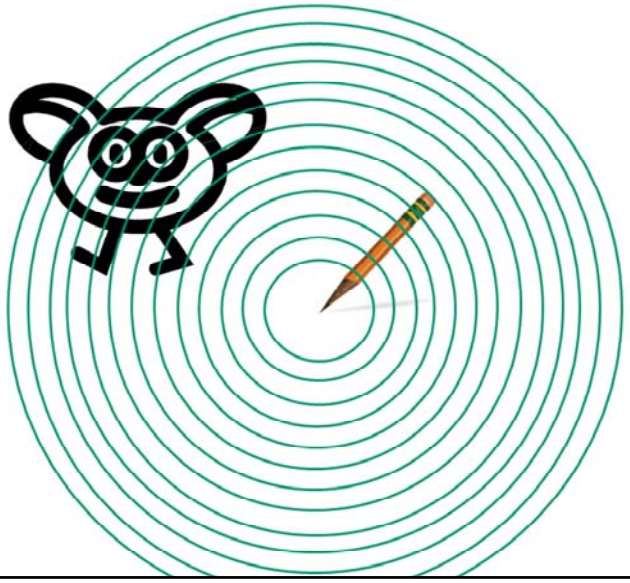
- Echolocators listen for the sounds bouncing back
- Most produce their own sounds (such as clicks) and listen for them to come back.
- People do this subconsciously

Results of Wednesday's Project:

- How many times did someone grab an object successfully?
- What was hardest location?
- Was everyone equally as good?

- Could you tell the short side of the room?

Locating sounds



Listen for the delay

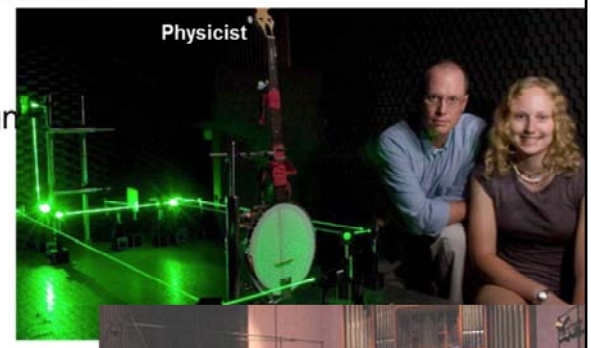
- The delay tells the brain how far away an object is.
- If one ear hears it first, then it knows the object is on that side.

Acousticians

- Animal bioacousticians
- Underwater acousticians
- P &P : Physical and Psychological
- Audiologists

Psychology

Acousticians



- Musical Instrument Design
- Speech scientist
- Medical acoustics

- Architectural acousticians
  - Concert Halls
  - Vibration (ie. Bridges)

Audi Sound Engineers

How many different types of acoustics jobs are included in this video?

MIT Museum

How many different types of acoustics jobs are included in this video?

- Musicians
- Marketing - Sound Designers
- Mechanical Engineers
- P &P (psychological)
- ….

Main Point: Audi is trying to create **a distinct sound** that is associated with their brand name and the marketing which goes into their product.

Their ability to reach their goal depends on how well their audio engineers and sound design team **understand basic principles in acoustics.**

Bob Coffeen

- 2012 Acoustics Education Prize

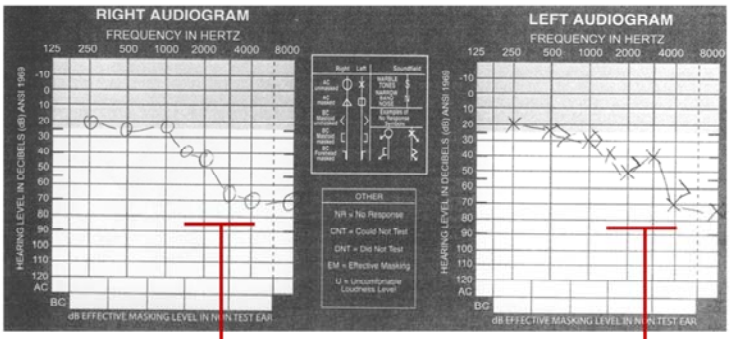
University of Kansas
School of Architectural
Design and Planning

- Acoustics is often not required

PLEASE NOTE THAT I WEAR HEARING AIDS…
AND SO WHAT!

I BEGAN USING HEARING AIDS SEVERAL YEARS AGO BECAUSE I WAS HAVING SOME PROBLEMS UNDERSTANDING STUDENTS IN MY CLASSES

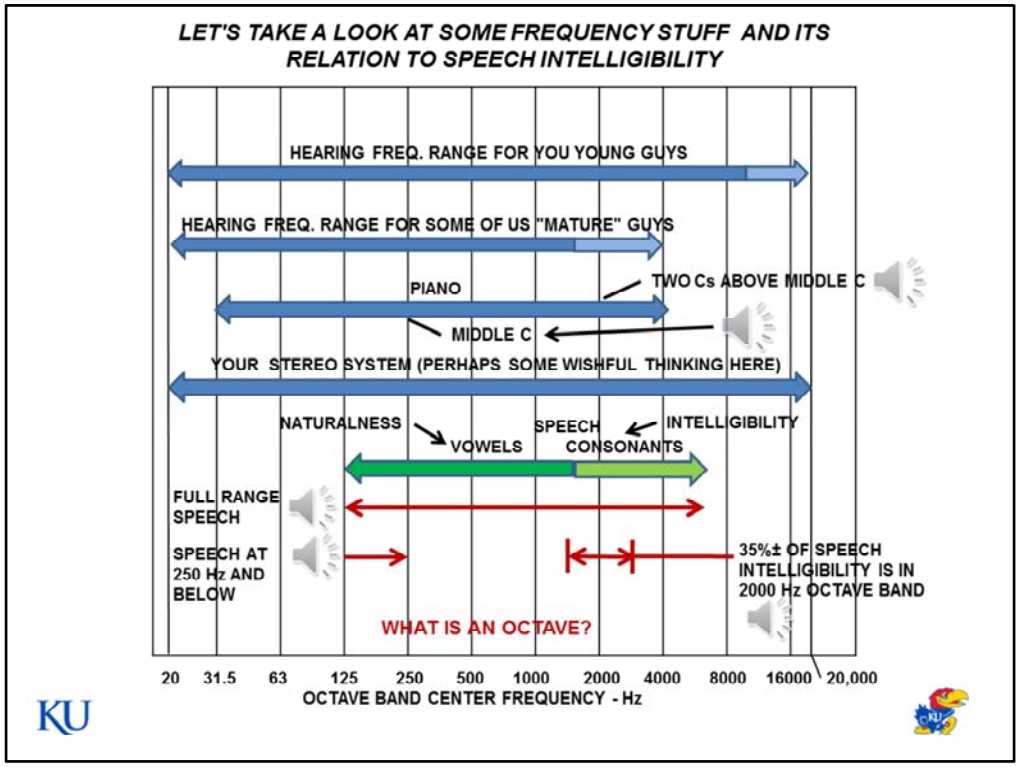
Slides courtesy of Bob Coffeen



THESE AUDIOGRAMS INDICATE THAT MY HIGHER FREQUENCY HEARING IS NOT DOING TOO WELL.

A COMPANY BUS AND TRUCK

MAYBE FLYING NOISY LIGHT AIRCRAFT FOR MANY YEARS, MOST OF THE TIME WITHOUT EAR PROTECTION


LET'S TAKE A LOOK AT SOME FREQUENCY STUFF AND ITS RELATION TO SPEECH INTELLIGIBILITY
HEARING FREQ. RANGE FOR YOU YOUNG GUYS
HEARING FREQ. RANGE FOR SOME OF US "MATURE" GUYS
PIANO
TWO Cs ABOVE MIDDLE C
MIDDLE C
YOUR STEREO SYSTEM (PERHAPS SOME WISHFUL THINKING HERE)
NATURALNESS
VOWELS
SPEECH
CONSONANTS
INTELLIGIBILITY
FULL RANGE SPEECH
SPEECH AT 250 Hz AND BELOW
35%± OF SPEECH INTELLIGIBILITY IS IN 2000 Hz OCTAVE BAND
WHAT IS AN OCTAVE?
20 31.5 63 125 250 500 1000 2000 4000 8000 16000 20,000
OCTAVE BAND CENTER FREQUENCY - Hz
KU

Main Entry: **oc·tave**
Pronunciation: 'äk-tiv, -t&v, -"tAv
Function: *noun*
Etymology: Middle English, from Medieval Latin *octava,* from Latin, feminine of *octavus* eighth, from *octo* eight -- more at EIGHT
Date: 14th century
1 : an 8-day period of observances beginning with a festival day
2 a : a stanza of eight lines **:** OTTAVA RIMA **b :** the first eight lines of an Italian sonnet
3 a : a musical interval embracing eight diatonic degrees **b :** a tone or note at this interval **c :** the harmonic combination of two tones an octave apart **d :** the whole series of notes, tones, or digitals comprised within this interval and forming the unit of the modern scale **e :** an organ stop giving tones an octave above those corresponding to the digitals
4 : the interval between two frequencies (as in an electromagnetic spectrum) having a ratio of 2 to 1
5 : a group of eight

KU

LET'S BACK UP A BIT…

WHAT IS SOUND?

One definition is…

Wave motion consisting of very small changes in air pressure which cause our eardrums (tympanic membrane) to "wiggle" (vibrate)

What two parameters must be identified to describe any sound?

Frequency (Pitch)

Amplitude (Intensity…Pressure)

How do we describe frequency?

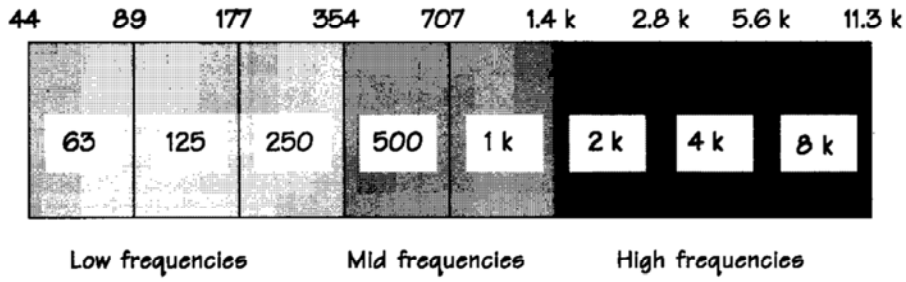
Repetition rate in

Cycles per second

Hertz (Hz)

How can we describe the frequency content of a sound?

By determining the sound pressure level within an octave frequency band or subdivisions of an octave band such as one-third octave band, one-sixth octave band, etc.



From Metha Johnson Rockafort text

The center frequencies of octave frequency bands have been standardized and are accepted the world over.

The upper and lower frequency limits can be determined as follows:

Upper limit = (center freq) $2^{1/2}$ = (center freq) 1.414

Lower limit = (center freq)/$2^{1/2}$ = (center freq) 0.707

THUS FAR WE HAVE TALKED ABOUT OCTAVE FREQUENCY BANDS. BUT, FOR HIGHER RESOLUTION IN DESCRIBING THE SPECTRUM OF A SOUND, WE OFTEN USE ONE-THIRD OCTAVE BANDS…

CENTER FREQ.- Hz	CENTER FREQ.- Hz
50	1000
63	1250
80	1600
100	2000
125	2500
160	3150
200	4000
250	5000
315	6300
400	8000
500	10000
630	12500
800	16000

STANDARD OCTAVE BAND CENTER FREQUENCIES ARE SHOWN IN RED

THE OCTAVE FREQ BAND CENTERED AT 250 Hz CONTAINS THE ONE-THIRD OCTAVE BANDS CENTERED AT 200, 250, AND 315 Hz

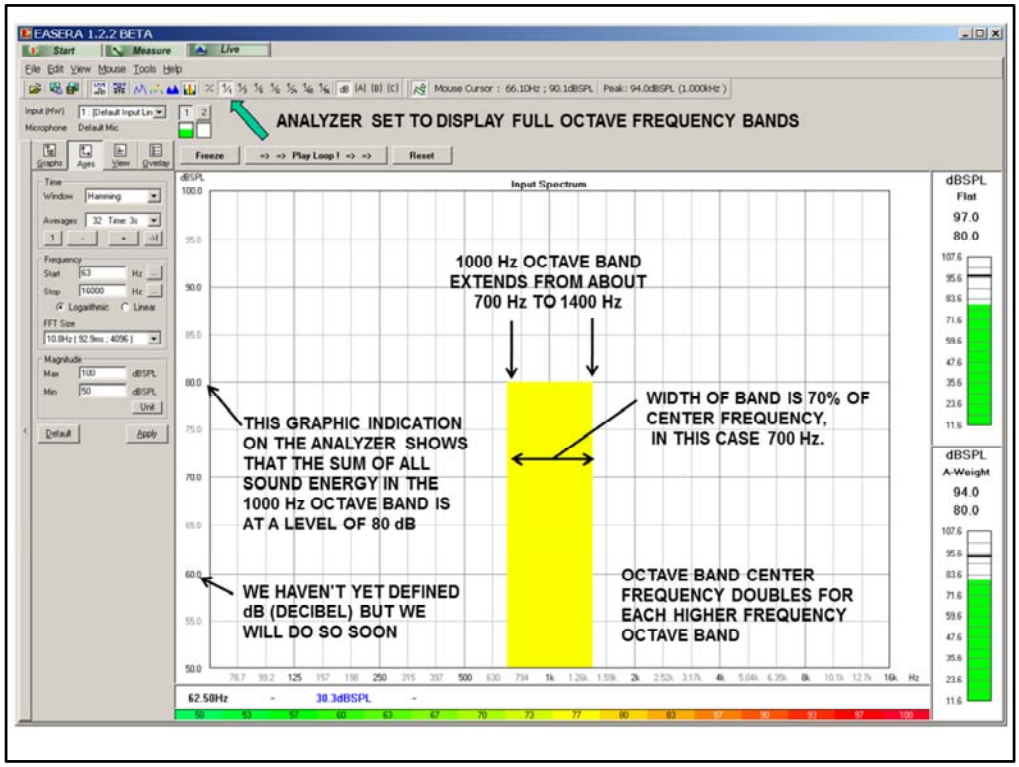
One-third octave bands are said to be 23 percent bands. The band width is approximately 23 percent of the center frequency.

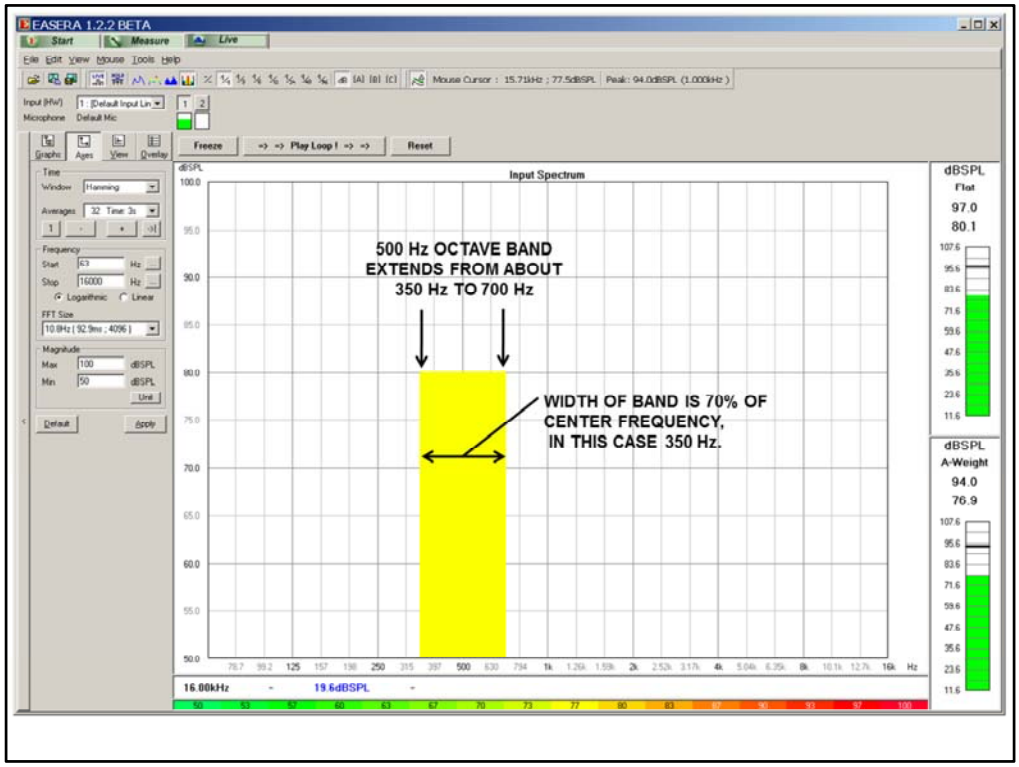
For octave bands the center frequency is multiplied by 2 to obtain the center frequency of the next higher band.

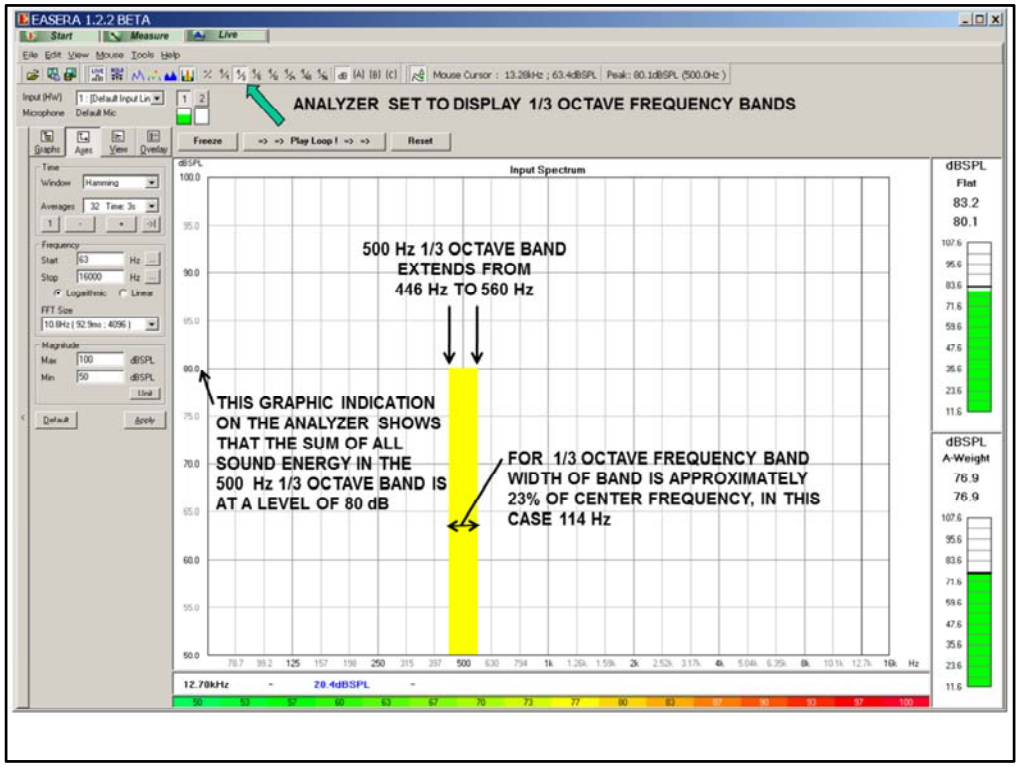
For one-third octave bands the center frequency of a 1/3 octave band is multiplied by $2^{1/3}$ (1.26) to obtain the center frequency of the next higher band.

Let's see how we can observe the frequency characteristics of a particular sound

WE'LL LOOK AT MEASUREMENTS FROM THE COMPUTER PROGRAMS
EASERA and systune


EASERA 1.2.2 BETA
ANALYZER SET TO DISPLAY FULL OCTAVE FREQUENCY BANDS
Input Spectrum
1000 Hz OCTAVE BAND
EXTENDS FROM ABOUT
700 Hz TO 1400 Hz
WIDTH OF BAND IS 70% OF
CENTER FREQUENCY,
IN THIS CASE 700 Hz.
THIS GRAPHIC INDICATION
ON THE ANALYZER SHOWS
THAT THE SUM OF ALL
SOUND ENERGY IN THE
1000 Hz OCTAVE BAND IS
AT A LEVEL OF 80 dB
WE HAVEN'T YET DEFINED
dB (DECIBEL) BUT WE
WILL DO SO SOON
OCTAVE BAND CENTER
FREQUENCY DOUBLES FOR
EACH HIGHER FREQUENCY
OCTAVE BAND
62.50Hz
30.3dBSPL


EASERA 1.2.2 BETA
Input Spectrum
500 Hz OCTAVE BAND
EXTENDS FROM ABOUT
350 Hz TO 700 Hz
WIDTH OF BAND IS 70% OF
CENTER FREQUENCY,
IN THIS CASE 350 Hz.
dBSPL
Flat
97.0
80.1
dBSPL
A-Weight
94.0
76.9
16.00kHz
19.6dBSPL

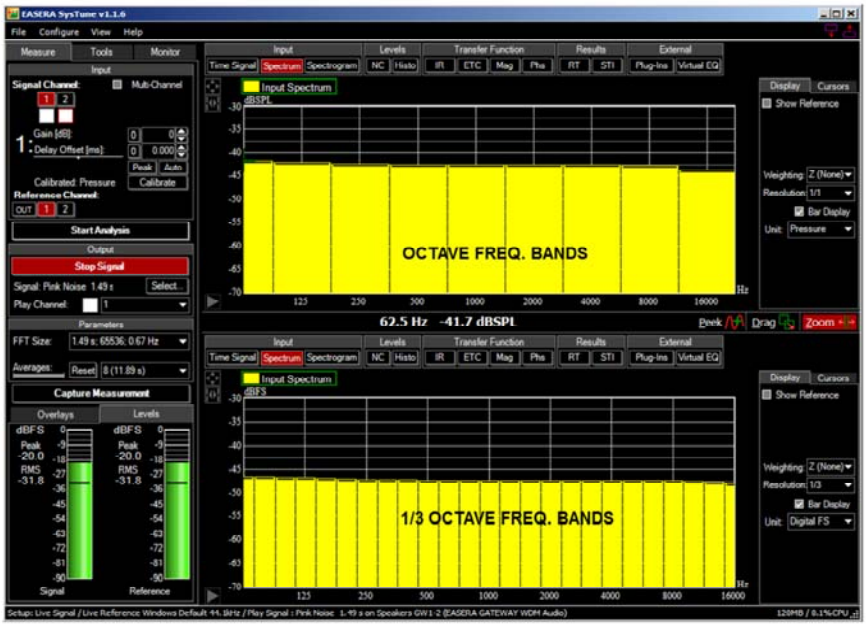

EASERA 1.2.2 BETA
ANALYZER SET TO DISPLAY 1/3 OCTAVE FREQUENCY BANDS
Input Spectrum
500 Hz 1/3 OCTAVE BAND
EXTENDS FROM
446 Hz TO 560 Hz
THIS GRAPHIC INDICATION
ON THE ANALYZER SHOWS
THAT THE SUM OF ALL
SOUND ENERGY IN THE
500 Hz 1/3 OCTAVE BAND IS
AT A LEVEL OF 80 dB
FOR 1/3 OCTAVE FREQUENCY BAND
WIDTH OF BAND IS APPROXIMATELY
23% OF CENTER FREQUENCY, IN THIS
CASE 114 Hz

Noise is often used as a test signal or for other uses.

What are the frequency characteristics of pink noise and white noise?

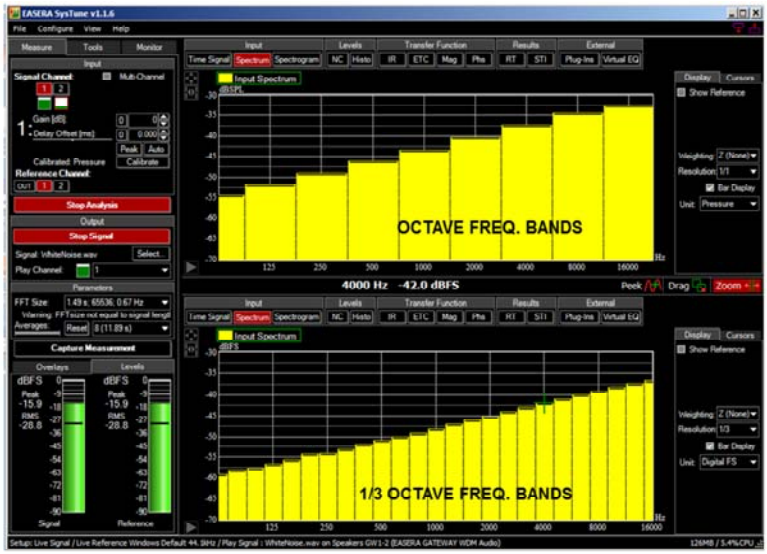
LISTEN TO PINK NOISE

PINK NOISE – EQUAL ENERGY IN EVERY "CONSTANT PERCENTAGE" BANDWIDTH…OCTAVE BAND, 1/3 OCTAVE BAND, ETC… APPEARS "FLAT" (OR NEARLY "FLAT") WITH FREQUENCY



LISTEN TO WHITE NOISE

WHITE NOISE – EQUAL ENERGY IN EVERY CYCLE...WHEN ANALYZED IN OCTAVE FREQUENCY BANDS THE LEVEL INCREASES WITH EACH HIGHER FREQUENCY OCTAVE BAND BY 3 dB. WHEN ANALYZED IN 1/3 OCTAVE FREQUENCY BANDS THE LEVEL INCREASES WITH EACH HIGHER 1/3 OCTAVE BAND BY 1 dB.



ANALYSIS BY EASERA SYSTUNE


Discovery of Sound in the Sea
Search
Home
Science of Sound
Animals and Sound
Audio Gallery
View Non-Flash Version of the Audio Gallery >
View 'Non-Flash' Version of Common Dolphin >
Marine Mammals - Toothed Whales
Common Dolphin (Delphinus spp.)
Picture:
Two common dolphins. Photo courtesy of NOAA Fisheries.
Click For Full Description
Category
Taxonomy
Select by Category
MARINE MAMMALS - TOOTHED
Copyright © Information
Marine Mammals - Toothed Whales
Amazon River Dolphin
Marine Mammals - Toothed Whales
Baiji
Marine Mammals - Toothed Whales
Marine Mammals - Toothed Whales

Frequency Attenuation

- Which travel further – high frequencies or low frequencies?

Dolphins

- Use lower sounds in captivity
- Use higher frequency in the wild

Why?

Whit Au discovered in 1974

Whit's answer

- First of all, absorption losses increase with frequency. So the higher the frequency the more the absorption losses will be for a given range.
- Secondly, the center frequency of the output signals tend to increase with amplitude. In other words, the higher the output the higher the frequency content will be.
- In small tanks, dolphins tend to use much lower amplitude bisonar signals than in large tanks or net-enclosure in open bays. The temporal resolution will be dependent of the bandwidth of the signal - higher bandwidth better resolution. The bandwidth tend to be wider for high frequency signals. So, in many situations, its hard to generalize since the biosonar signals dolphin use depends on the specific situation. Their system seems to be very flexible so dolphins tend to adapt to the situation.